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Staged-Volume Fan Control

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Description

Perhaps the most common HVAC system sold in California today is the packaged single-zone rooftop system in the 7-1/2 to 15 ton range. These units commonly have two stages of heating and two stages of cooling. Attention has been given to increasing the heating and cooling efficiencies of these units, and while further gains are possible, the gains will be incrementally small and relatively expensive. However, little attention has been given to the fans, even though the fans may consume as much or more energy than the compressors on an annual basis.

A electronic variable-speed drive (VSD) that stages fan output with the heating/cooling staging can typically cut the annual fan energy by more than half, resulting in an annual efficiency gain of 25% for the HVAC system.

The Standards should consider requiring VSDs, or equivalent unloading mechanisms, for all packaged single-zone systems 7-1/2 tons and larger having 2-stages of heating/cooling.

Benefits

Since staging the fan output can cut annual fan energy consumption in half, and since fan energy typically comprises 20% of a small commercial building's electrical consumption, this technology can cut a building's annual electrical consumption by 10%.

In addition to the energy savings, this concept can enhance comfort via improved humidity control:

1. Years ago, split-face coils were common in two-compressor DX units. When one compressor was running, half of the coil face was active. The portion of air flowing through that half of the coil would be cooled to 55°F and dehumidified in the process. This air then mixed with the air flowing through the non-active half of the coil, and flowed on to the space at the intermediate temperature.
2. Manufacturers have moved to interlaced refrigerant circuits, so that the entire coil face is active when only one compressor is running. While this improves the SEER of the unit, the stage-one dehumidification is less than before. In those portions of the State having relatively high humidity, the decreased comfort may result in thermostat setpoints lower than they would be otherwise.
3. The staged-volume concept reduces airflow during stage-one cooling, thereby lowering the supply temperature and improving the dehumidification.

Time dependent valuation would reduce the benefits of this measure, as the energy savings will accrue principally in the non-peak hours. However, since packaged units come in discrete sizes, and engineers normally apply a safety factor to their load calculations, savings during on-peak periods are also expected. In fact, this technology can allow a reasonably oversized system to be more efficient than a system exactly sized to meet the load.

Environmental Impact

VSDs can create harmonic distortion on power lines, which can affect sensitive electronic equipment and can reduce the power factor of a building. These effects are commonly mitigated using filters.

The manufacture of VSDs shares the same environmental considerations as the electronic industry in general.

In units having a fixed minimum outside-air damper position, indoor air quality may suffer when the airflow is reduced. However many units in this size range have an outside-air flow sensor which adjusts the damper position to maintain the required airflow.

Type of Change

Prescriptive Requirement — The change would add or modify a prescriptive requirement. Prescriptive requirements must be met for prescriptive compliance and define the Standards baseline building in performance calculations, but are not mandatory when the performance approach is used.

The proposed change expands the existing scope of the standards, requiring that packaged constant-volume systems with 2 stages of heating/cooling actually be variable flow, with the flow staging with the heating/cooling staging.
This change would affect all documents: Standards, ACM, manuals, and compliance forms.

Measure Availability and Cost

Electronic VSDs have been available for over 15 years, are now considered highly reliable, and the manufacturers are well-known to HVAC designers and mechanical contractors.
For packaged-rooftop equipment, manufacturers may require lead time to re-engineer their cabinets to accommodate the VSD.
For life cycle cost analysis, the baseline conditions would be current Standards.
The cost varies by size, with larger sizes costing less per horsepower than smaller sizes. The contractor cost (uninstalled) is approximately $800 for a 10 horsepower VSD. Bulk purchases by the manufacturers should reduce this cost. Net installed cost is expected to be on the order to $2,000.

Useful Life, Persistence and Maintenance

VSDs have matured considerably over the last 10 years, and the technology is different than it was 10 years ago. The currently generation of drives are expected to last at least 10 years, but is too new to have been demonstrated for that period.
Energy savings will be consistent over the life of the equipment.

Performance Verification

As this measure will be factory installed, it will require little or no additional field effort to verify performance.

Cost Effectiveness

Preliminary analyses indicate typical paybacks of 1-2 years. More detailed studies are underway to refine this estimate.

Analysis Tools

DOE-2 is being modified to incorporate this control strategy for packaged-single zone units. These modifications will be available in the freeware version in the near future.

Relationship to Other Measures

No other measures are impacted by this change.

Bibliography and Other Research

Research is currently underway by SCE, with Hirsch & Associates as the lead contractor. Results will be available